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DESIGN STRATEGIES FOR A COMPLEMENTARY NATURE-CONNECTED INDOOR-OUTDOOR ENVIRONMENTS TO FOSTER CHILDREN'S HOLISTIC DEVELOPMENT: A REVIEW

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Abstract

Reconnecting children with nature through a high-quality indoor and outdoor environment is crucial for supporting children's holistic developmental needs, such as cognitive, physical, social, and emotional growth. Nature has a long history of contributing to children's development, but today's children are disconnected from the outdoor environment where they can engage with nature directly. Indoor environments and spaces, however, also play an important role in reconnecting children with nature. Hence, it is crucial to better understand the natural context and design elements for both indoor and outdoor environments that support children's holistic development. Based on a systematic review, this paper presents a review of indoor and outdoor nature's contribution to children's development. This review highlights the importance of children's indoor and outdoor environments, which complement each other in contributing to their development. Views of nature, indoor plants, green walls, and natural lighting are important indoor design elements that need to be considered in designing children's indoor spaces. Meanwhile, green areas and natural play spaces are fundamental for children's development in the outdoor environment. The findings provide a foundation for design strategies aimed at integrating multi-natural environments in both indoor and outdoor environments and spaces to foster children's holistic development. Directions for future research are also outlined.

Keywords: Nature, Indoor-Outdoor, Children, Biophilic, Design

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INTRODUCTION

According to the United Nations Convention on the Rights of the Child 1989, children have the right to enjoy a high-quality environment that supports their developmental needs (United Nations, 2010). Hence, it is crucial to provide a such an environment including a physical environment that supports children's development. For the past two decades, numerous studies have demonstrated the importance of nature for children's holistic developmental needs (Mustapa et al., 2015; Mårtensson et al., 2014) as well as the well-being of the environment (Cheng & Monroe, 2010; Hinds & Sparks, 2008). Many studies have demonstrated that children appreciate and are very attracted to the natural environment (Mahidin & Maulan, 2012; Said & Abu Bakar, 2005), specifically, places that have trees and flowers (Castonguay & Jutras, 2009). The bonding between children and nature can be explained by ecopsychology perspectives that claim children have an innate feeling of being connected with nature since birth (Phenice & Griffore, 2003).

Recently, 1 in 6 children has been found to suffer from mental health problems, with 16.5% of children aged 5 to 15 years old facing mental health issues (National Health and Morbidity Survey, 2023) such as stress and anxiety. In turn, children encounter problems in cognition such as poor attention and concentration (Cardoso-Leiti et al., 2021). Nature has abundant benefits for children's development, health, and mental well-being (Muhsein et al., 2024; Mustapa et al., 2024). Nevertheless, for the past few years, children have become disconnected from nature. Studies have shown that the number of children playing in the outdoor environment, specifically near their home and in in neighbourhood areas where nature exists, is declining (Clements, 2004; Karsten, 2005), and this has led to children being disconnected from nature (Chawla & Derr, 2012; Myers, 2012). Also, children's trends of being active in outdoor environments have changed to children being confined to indoor environments with gadgets (Mustapa et al., 2019). Furthermore, children who have a weaker connection with nature as a consequence of this disconnection from nature will display apathy towards the environment (Mustapa et al., 2020). Hence, reconnecting children with nature has become an increasing concern

Given that reconnecting children with nature in the built environment is essential for children's developmental needs, such as cognitive, physical, social, and emotional growth and for their health and well-being, this paper aims to provide a review as a foundation for understanding the benefits of nature through multi-environmental design elements in both indoor and outdoor settings for children's. Despite increasing interest, there is only limited information on the overall contribution the indoor-outdoor nature-connected environments to children's well-being. A review by Meng et al. (2023) provides information on the effect of the visual indoor environment on children's health, while other

studies focus on the outdoor environment (Chawla, 2015; Mustapa et al., 2015). The findings from this review can form a basis for design strategies integrating nature-connected indoor-outdoor environments into the planning and design of the built environment. This study focuses on the benefits of indoor and outdoor environments on children's developmental needs and the importance of indoor-outdoor environments, places, and spaces to reposition nature in a way that will support such needs.

LITERATURE REVIEW

Children, Nature, and Environment

Children are shaped by their environment, and thus the environment is an important milieu for children's development. A good physical environment benefits children's development, health, and well-being (Mustapa et al., 2015). Over the past few decades, many studies have shown that nature contributes to children's development, including their cognitive, physical, social, and emotional growth. Studies have shown that exposure to nature can help to reduce children's stress, improve their mood, and increase their happiness (Liu & Green, 2023; Mustapa et al., 2015, 2024). The outdoor environment becomes children's preferred place to play, as they can experience the freedom to play and socialize with their peers (Said, 2012). However, as most people, including children, spend over 90% of their day indoors (Gonzalez-Martin et al., 2021), the importance of the indoor environment has also become a concern. It is essential to provide a high-quality indoor environment for children. Indeed, indoor environments also play a vital role in contributing to children's development, health, and well-being (Meng et al., 2023). For example, a study by Sandseter et al. (2022) demonstrated that children's indoor environment offers better opportunities for constructive and symbolic play through natural elements; however, functional play through physically active play is found more often associated with outdoor environments, where children can explore more and is less frequently found in indoor environments.

The Attributes of Nature in the Built Environment

In the 21st century, biophilic design, which originated from the biophilia hypothesis, has been introduced. Based on Heerwagen and Hase (2008), nature can be conceptualized differently in architecture. The most commonly used frameworks by many researchers are those by Browning and Ryan (2014) and Kellert (2018). Browning and Ryan's (2020) framework includes Nature in the Space (visual connection with nature, non-visual connection with nature, non-rhythmic sensory stimuli, thermal and airflow variability, presence of water, dynamic and diffused light, connection with natural systems), Natural Analogues (biomorphic forms and patterns, material connection with nature and complexity

and order) and Nature of the Space (prospect, refuge, mystery, risk/peril, and awe). On the other hand, Kellert's (2018) framework includes direct experiences of nature (light, air, water, plants, animals, landscapes, weather, views, and fire), indirect experiences of nature (images, materials, textures, colours, shapes and forms, information richness, time changes, geometries, stimulated natural light and air, and biomimicry), and experiences of space and place (prospect and refuge, organized complexity, mobility, transitional spaces, place, and integrating parts to create wholes). These design patterns have various applications for indoor and outdoor environments and illustrate the relationship between human biology, nature, and the built environment.

RESEARCH METHODOLOGY

Literature searches on the benefits of nature in indoor and outdoor environments on children's developmental needs were conducted from SCOPUS and WOS databases including Science Direct, SAGE, Springer, and Taylor and Francis. Using the combination of keywords (children, nature, natural environment, biophilic, indoor plants, natural ventilation, natural lighting, view of nature, material, cognitive, physical, social, and emotional), relevant journals were identified. The journals were from different disciplines: children's environment, environmental psychology, environmental design, health and place, environment and behaviour, environmental education and building and environment, and sustainable cities and society. This review paper selected only empirical papers published between 2015 to 2025 and related to the benefits of nature on children's developmental needs in both indoor and outdoor contexts. Hence, this review includes studies on nature in early childhood, middle childhood, and early adolescence. In total, 65 journals were found, but only 23 empirical papers were selected. This review emphasizes the benefits of nature in both indoor and outdoor settings on children's developmental needs and categorizes them as cognitive, physical, social, and emotional. This review also highlights the environment, places, and spaces in both indoor and outdoor settings that are important in connecting children with nature.

ANALYSIS AND DISCUSSION

Nature in Outdoor and Indoor Environments that Contribute to Children's Cognitive, Physical, Social, and Emotional Development

This review elucidates that studies on nature and children have been conducted in different settings, such as green areas in neighbourhoods (Buczyłowska et al., 2024; Reuben et al., 2019; Singh et al., 2024), schools (Amicone et al., 2018; Dadvand et al., 2015; Kuo et al., 2021), and natural play spaces (Prins et al., 2023; Zamani, 2016) as shown in Table 1. The school environment and spaces have

become a frequent focus for research on and with children since children spend most of their time at school. The natural context and natural design elements found have been categorized into indoor and outdoor environments. The outdoor environment includes green areas and natural play spaces. Meanwhile, indoor environment studies comprise research on views of nature, natural lighting, indoor plants, and green walls. Also, the researchers have started to focus on exploring the impact of biophilic design at school on children's developmental needs, which have been categorized into indoor and outdoor environment categories. The impact of nature on both indoor and outdoor environments has been mapped to children's cognitive, physical, social, and emotional development (refer to Table 1).

Table 1: Natural Context and Natural Design Elements and their Contribution to Children's Development

Natural Context/ Natural Design Elements	Cognitive	Physical	Social	Emotional
Indoor Environment				
Views of nature from inside (window) (Primary school and high school)	Increase focus, and improve cognitive skills and academic performance. Li & Sullivan (2016), Lindemann- Matthies et al. (2021), Pearson et al. (2023), Studente et al. (2016)	-	-	Enhance positive mood and happiness. Charlotte et al. (2022), Li & Sullivan, (2016), Mustapa et al. (2024)
Natural lighting (Primary school)	Improve concentration and increase achievement. Baloch et al. (2020), Oppusunggu & Santoso (2024)	-	-	Increase positive mood. Mustapa et al. (2024)
Indoor plants and green wall (Primary school)	Increase focus and improve academic achievement.	-	-	Improve mood, and foster a more relaxed and positive atmosphere

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Natural Context/ Natural Design Elements	Cognitive	Physical	Social	Emotional
	Bernardo et al. (2021), Lindemann- Matthies et al. (2021), Mustapa et al. (2024), van de Bogerd et al. (2020), van den Bogerd et al. (2017)			conducive to learning. Charlotte et al. (2022), Mustapa et al. (2024), van de Bogerd et al. (2020), van den Bogerd et al. (2017)
Outdoor Environment				
Green areas (Neighbourhood and school)	Improve attention and academic performance. Amicone et al. (2018), Dadvand et al. (2015), Kuo et al. (2019, 2021), Reuben et al. (2019)	Increase motor development. Buczyłowska et al. (2024), Kuo et al. (2019), Singh et al. (2024)	Foster interaction with peers. Buczyłowska et al. (2024), Kuo et al. (2019)	Lower stress levels. Amicone et al. (2018), Kuo et al. (2019)
Natural play space (Natural elements such as trees, sand, water, and vegetation) (Primary school and preschool)	Enhance problem-solving skills and creativity. Prins et al. (2023), Zamani (2016)	-	Foster interaction with peers. Zamani (2016)	Give restorative effect. Bagot et al. (2015)
Indoor and Outdoor Environment				
Biophilic design (Primary school)	Enhance creativity and problem-solving abilities, focus and motivation. Abdul Malek et al. (2024), Barbiero et al. (2021)	-	-	Improve positive mood, increase happiness, and give restorative effect. Abdul Malek et al. (2024), Barbiero et al.

Natural Context/ Natural Design Elements	Cognitive	Physical	Social	Emotional
				(2021), Ghaziani et al. (2021), Mustapa et al. (2024)

Indoor Environment

Views of Nature from Inside (Window)

Views of nature play an important role in children's cognitive and emotional development. Studies have found that views of nature from inside through windows can significantly increase children's cognitive skills, increase focus and visual creativity, and improve academic performance (Li & Sullivan, 2016; Lindemann-Matthies et al., 2021; Pearson et al., 2023). For example, studies have demonstrated that children's attention increases in classrooms with window views of green landscapes (Li & Sullivan, 2016; Lindemann-Matthies et al., 2021). Similarly, studies by Lindemann-Matthies (2016) and Pearson et al. (2023) have demonstrated that children reported being more focused on tasks in classrooms with more natural window views. Meanwhile, in a study by Studente et al. (2016), children's visual creativity increased by exposure to natural views, plants, and the colour green. Emotionally, the presence of a window view towards greenery reduces children's stress and anxiety (Charlotte et al., 2022). Also, window views of green landscapes speed up children's recovery from stress (Lindemann-Matthies et al., 2021). A study by Mustapa et al. (2024) also found that a view of nature from a classroom enhances children's positive mood and happiness providing a refreshed feeling, and hence they can be more focused during learning.

Indoor Plants and Green Wall

Studies have demonstrated that indoor plants and green walls affect children's cognitive and emotional development. Cognitively, children are reported to have greater attention in indoor classrooms with plants than in classrooms without plants (van den Bogerd et al., 2020). Similarly, a study by Mustapa et al. (2024) found that the presence of indoor plants in learning spaces including classrooms gives a feeling of calmness, and thus children can focus better during learning. Potted vegetable plants also significantly increased attention and work memory in a study between the experimental and a control group (Bernando et al., 2021). Green walls were also found to have a significant impact on children's attention. A study by van de Bogerd (2017) showed that children in four classrooms with green walls scored better on a test for selective attention compared with children

in classrooms without green walls. Emotionally, the presence of green walls has also been shown to reduce children's stress and anxiety levels (Charlotte et al., 2022). The presence of indoor plants and green walls in classrooms fosters a more relaxed and positive atmosphere that is conducive to learning and improves indoor air quality; thus, children have a positive mood and greater happiness during learning (Charlotte et al., 2022; Mustapa et al., 2024; van de Bogerd et al., 2020; van den Bogerd et al., 2017).

Natural Lighting

Natural lighting also plays an important role in children's cognitive and emotional development. Natural lighting for school interiors has been found to affect children's eyes, which in turn impacts their vision, observation skills, and ability to receive information, thus contributing to their overall cognitive development (Oppusunggu & Santoso, 2024). Another study by Baloch et al. (2020) demonstrated a positive relationship between performance scores and type of window shading, latitude, percentage of the window facing south, and window glazing, with the highest impact due to the window-to-floor area ratio that allows natural lighting. Another study by Mustapa et al. (2024) found that children prefer classrooms with sufficient daylight, as it makes them feel calm and allows them to focus on learning.

Outdoor Environment

Green areas

Studies have demonstrated that green areas in neighbourhoods and surrounding schools play an important role in children's holistic development, particularly their cognitive, physical, social, and emotional needs. Cognitively, studies have demonstrated that being in and walking in green areas improves children's attention, concentration, memory span, and academic performance (Amicone et al., 2018; Dadvand et al., 2015; Kuo et al., 2019, 2021; Reuben et al., 2019). For example, in a study by Kuo et al. (2021), children performed better in reading and maths tests when there was greenness within 250m of their school. Another study by Singh et al. (2024) demonstrated that attention for children with and without Attention Deficit Hyperactive Disorder (ADHD) improves when the children are surrounded by trees or in domestic gardens, or if there are water bodies in the neighbourhood areas. Physically, the diversity of natural elements in green areas allows children to be explorative and further increases their motor skills (Buczyłowska et al., 2024; Kuo et al., 2019; Singh et al., 2024) and subsequently fosters interaction with their peers (Kuo et al., 2019; Singh et al., 2024). Also, physical activity while being under tree cover and in gardens was found to provide higher social cohesion and lower children's ADHD (Buczyłowska et al., 2024). Emotionally, green areas significantly lower children's stress and have a

restorative effect (Amicone et al., 2018; Kuo et al., 2019); children were found to perceive greater restorativeness from the pre-test to the post-test after being in green areas in school during recess time (Amicone et al., 2018).

Natural Play Space

Natural play spaces and playgrounds also have an important role in children's cognitive, physical, social, and emotional development. Various natural elements in natural play spaces provide affordance for children to play. Those elements enhance children's creativity and problem-solving skills (Prins et al., 2023; Zamani, 2016). A study by Zamani (2016) showed that incorporating natural features and settings in outdoor preschools supports a diverse spectrum of cognitive play by inspiring children's imagination, social engagement, and games. The diversity of natural elements in natural play spaces also stimulates children's social skills, as children start to communicate with peers during play (Zamani, 2016). Emotionally, vegetation volume has been found to be significant in predicting perceived restorativeness. Smaller and greener playgrounds were found to yield the strongest restorative benefits (Bagot et al., 2015).

Indoor and Outdoor Environment

Biophilic Design

Studies have demonstrated that biophilic elements in both indoor and outdoor environments make a crucial contribution to children's cognitive, social, and emotional development. A study by Mustapa et al. (2024) found that connection to natural systems (views towards nature) and dynamic and diffuse light are the most crucial biophilic elements that need to be imparted in children's spaces to enhance children's well-being. Views towards greenery from inside the classroom, as well as natural light coming into the learning spaces, give children a feeling of calmness and refreshment so they can focus on their learning. Natural ventilation is also preferred, as it elevates children's positive emotions and reduces stress. Meanwhile, in a long-term study by Barbiero et al. (2021), children preferred the nature-based classroom compared to the conventional classroom. Children were found to be more focused in nature-based classrooms, which have restorative effects, and this increased their affiliation with nature. Similarly, a study by Abdul Malek et al. (2024) indicated that biophilic elements such as animals (pets), natural lighting, and water elements are the most preferred; they contribute to children's calmness and well-being and help them develop a connection with nature.

Design Strategies for Integrating Nature in Children's Indoor and Outdoor Environments

Designing indoor and outdoor environments that incorporate nature is vital to support children's development. For the indoor environment, the review highlights the most important design elements, such as views of nature, indoor plants or green walls, and natural lighting coming into the spaces, which play an important role in fulfilling children's cognitive and emotional developmental needs. Meanwhile, green areas and natural play spaces in neighbourhoods and schools are vital for the outdoor environment to support children's holistic development. Hence, rethinking and repositioning nature is vital in children's habitual range, particularly the innermost zone, including at home, the home yard, play spaces, and the neighbourhood. Furthermore, repositioning and reconnecting with nature in children's frequent range, particularly, the intermediate zone, which is at school, is also crucial, as children spend most of their time learning at school (see Figure 1).

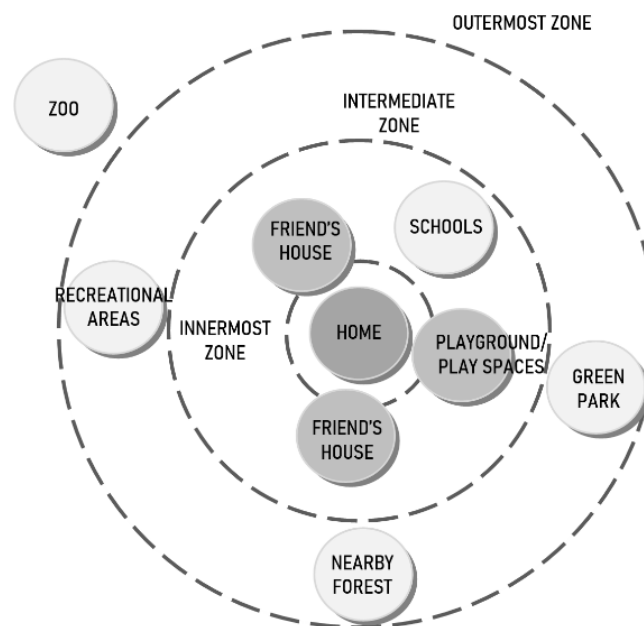


Figure 1: Children's Environment Range

Source: Author

As children increasingly spend more time indoors, integrating nature into their everyday environments at home, and in play spaces, neighbourhoods, and schools is essential for their development, health, and well-being. At home, nature can be introduced through domestic gardens, indoor plants, green walls, and balconies, especially for those living in high-rise buildings. Beyond the home, children's play spaces and neighbourhood areas should prioritise natural elements. Designers and planners play a key role in replacing conventional playgrounds with natural playgrounds that encourage creative play, independent mobility, and exploration. Exposure to diverse natural elements in parks and neighbourhoods provides both direct and indirect experiences with nature, positively influencing children's emotional and cognitive well-being. Schools are particularly important settings, as children spend a significant amount of time there. The implementation of green school grounds and biophilic design, such as views of nature, indoor plants, green walls, natural lighting, ventilation, and water elements, can enhance children's focus, academic performance, and emotional well-being. Even indirect exposure to nature through classroom windows contributes positively. Overall, the thoughtful integration of nature across children's daily environments is vital in supporting holistic development and fostering a lasting connection with nature.

CONCLUSION

The synthesis confirms that the presence of nature in indoor and outdoor environments is vital for children's holistic development: cognitive, physical, social, and emotional. Both indoor and outdoor contexts play an important role in contributing to children's development, as different natural contexts and design elements contribute differently and complement each other. All natural contexts complement each other, as the indoor environment contributes more to the cognitive and emotional aspects of children's development, while the outdoor environment can contribute to their holistic development. This review highlights the importance of green areas, natural play spaces, views of nature, indoor plants and green walls, and natural lighting on children's cognitive, physical, social, and emotional. Views of nature, indoor plants and green walls, and natural lighting seem to be important design criteria to be considered for implementation in indoor contexts, such as in school classrooms. Meanwhile, in the outdoor environment, green areas and natural play spaces, especially in the neighbourhood context and the school, make a crucial contribution to children's holistic development.

In addition, schools in children's intermediate-range can be seen as an important environment that supports children's holistic developmental needs as they spend most of their time at school. The findings suggest that a combination of a multi-environment design in the built environment can help to promote

children's holistic development. The practitioners in the built environment, including architects, interior architects, and landscape architects, should play an important role in reconnecting children with nature. Educators can also help by designing spaces that incorporate nature into school classrooms, while parents should have a better understanding of the benefits of nature, and so provide their children with access to nature even in their home yard and inside the home. Future research can be conducted to explore other natural contexts and elements that contribute to children's development and well-being, and investigate further the impacts of indoor-outdoor nature-connected environments towards creating a sustainable environment and facilitating the sustainability of future generations.

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